TOLL BRIDGE PROGRAM OVERSIGHT COMMITTEE

Final Agenda

TBPOC CONFERENCE CALL
May 7, 2013, 8:00am – 9:00am

	Topic	Presenter	Time	Desired Outcome
1.	**CHAIR'S REPORT**	S. Heminger, BATA		Information
2.	**SAN FRANCISCO-OAKLAND BAY BRIDGE UPDATES**			
	a. Calendar of Upcoming Events: 1) BATA Oversight Committee May 8 meeting 2) TBPOC May 9 meeting 3) CA Senate May 14 hearing 4) TBPOC May 15 workshop 5) Special BATA Commission May 29 meeting	PMT	10 min	Information
	b. BATA Oversight Committee May 8 Draft Presentation*	PMT	40 min	Approval
	c. TBPOC Letter to FHWA*	PMT	5 min	Approval
	d. Caltrans Draft Report – Metallurgical Analysis of Bay Bridge Broken Anchor Rods S1-G1 and S2-A6	PMT	5 min	Approval
3.	**OTHER BUSINESS**			

Next TBPOC Meeting: May 9, 2013, 1:00pm – 4:00pm
1120 N Street, Sacramento, CA

* Attachments
**Attachments at end of binder
***Attachments to be sent under separate cover

Briefing on E2 Anchor Bolts – May 8, 2013

Four Key Questions

1. What caused the E2 anchor bolts manufactured in 2008 to fail?

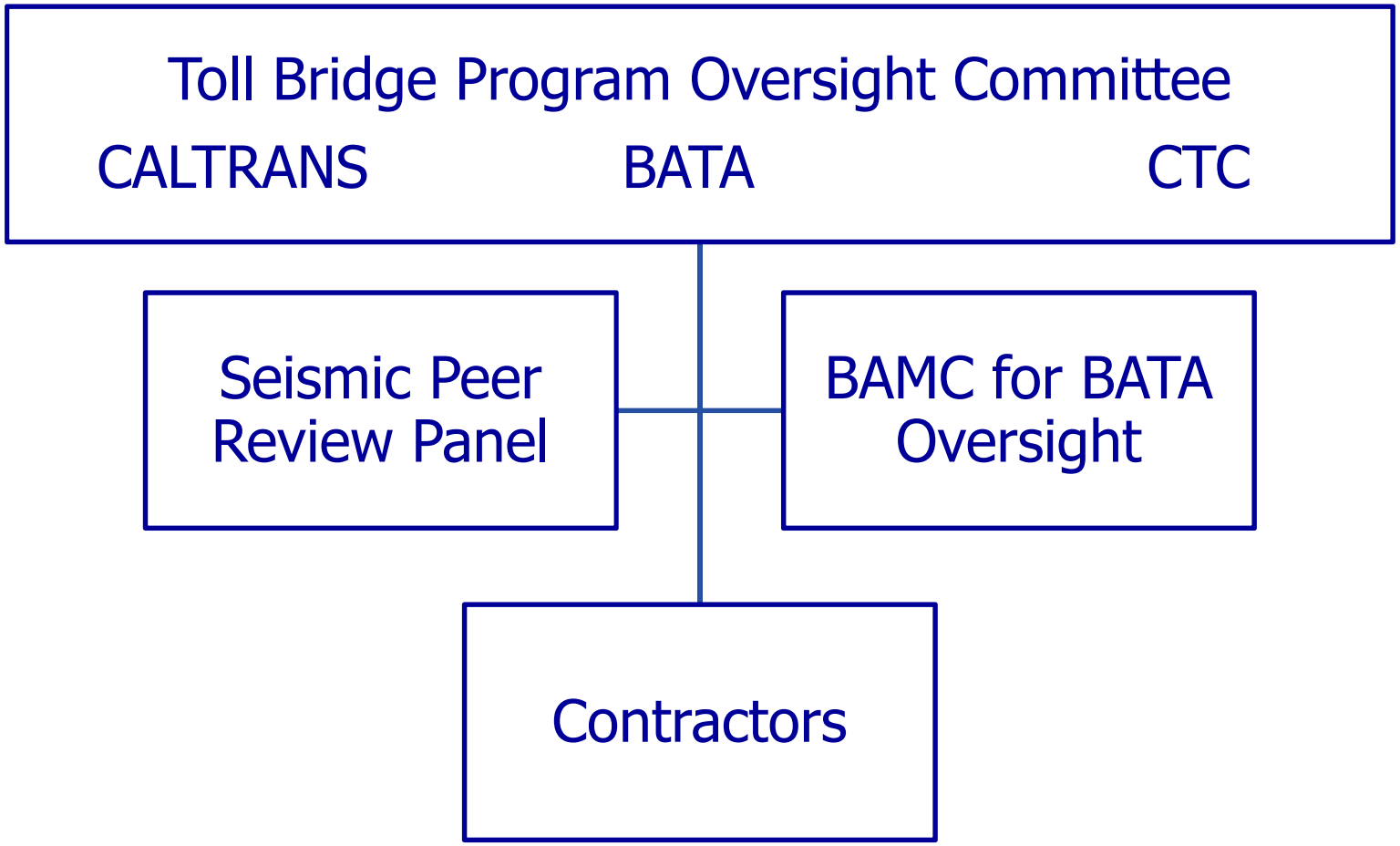
2. What retrofit strategy should be used to replace the 2008 anchor bolts?

3. Should the remaining bolts on the E2 pier manufactured in 2010 be replaced?

4. What should be done about the other A354 BD bolts on the SAS?


Pier E2

Oversight Structure



Toll Bridge Program Oversight Committee

- **AB 144 established the *Toll Bridge Program Oversight Committee*, composed of Director of the California Department of Transportation (Caltrans), and the Executive Directors of the California Transportation Commission (CTC) and the Bay Area Toll Authority (BATA), to be accountable for delivering the Seismic Retrofit Program.**

MALCOLM DOUGHERTY
Director
California Department of Transportation

STEVE HEMINGER
Executive Director
Bay Area Toll Authority

ANDRE BOUTROS
Executive Director
California Transportation Commission

Toll Bridge Seismic Peer Review Panel

- **Dr. Frieder Seible, Dean Emeritus of the Jacobs School of Engineering at the University of California at San Diego, has consulted on many of the world's long-span bridges and has extensively published related to seismic design and blast resistant design of critical structures.**

- **Dr. I.M. Idriss, Emeritus Professor of Civil Engineering at the University of California at Davis , is a Geotechnical Engineer who has performed follow-up analysis of every major earthquake since the 1964 Alaska quake and has been part of the engineering teams to analyze damage and determine causes of structural collapse.**

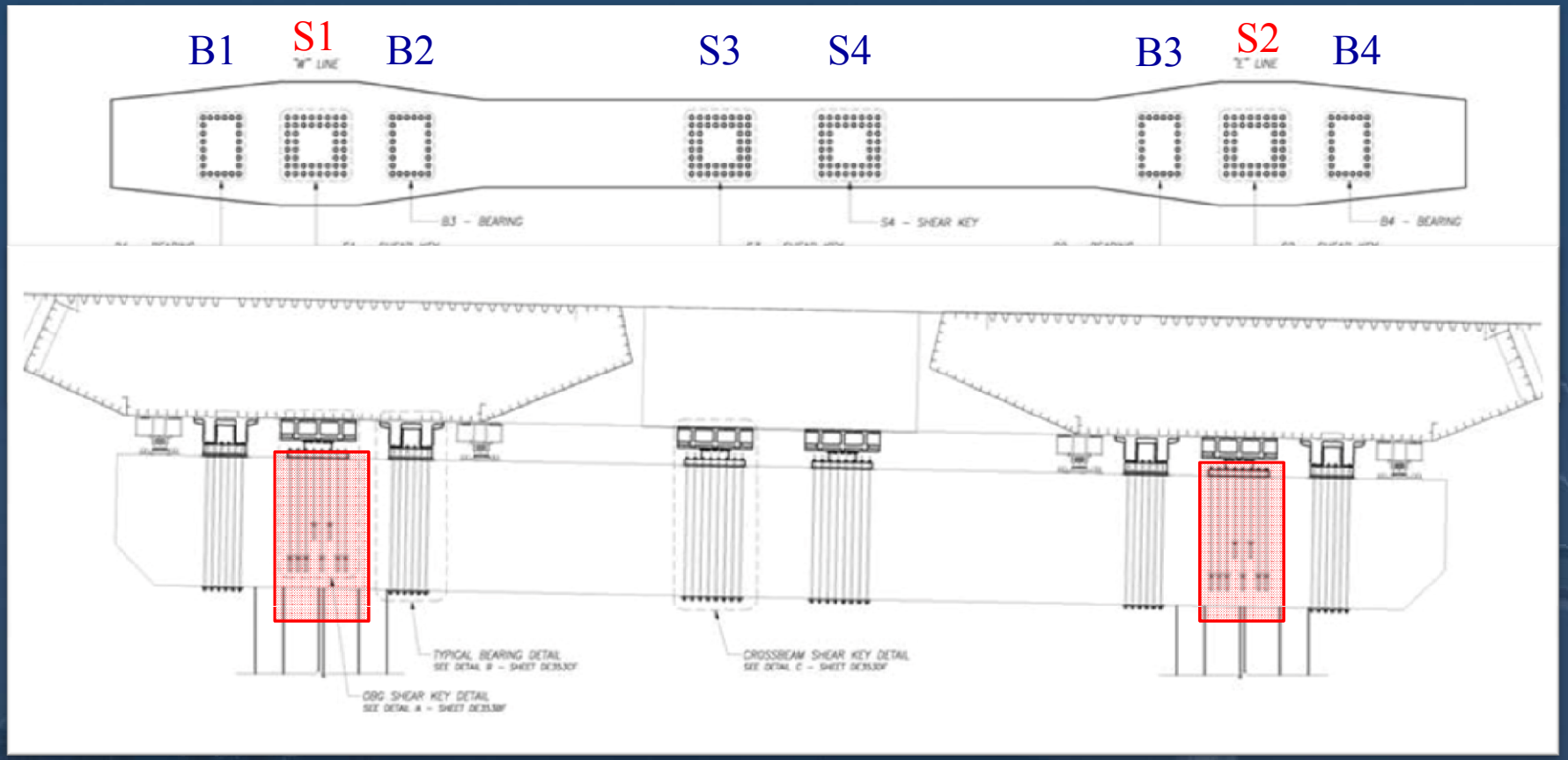
- **Dr. John Fisher, Professor Emeritus of Civil Engineering at Lehigh University, has focused his research on the behavior and performance of steel bridges and has examined most of the major failures of steel structures in America throughout the last four decades, including the World Trade Center in 2001.**

- **All three are members National Academy of Engineering.**

FHWA Independent Review

- **The TBPOC has requested that the Federal Highway Administration (FHWA) conduct an additional independent review of our findings and recommendations concerning the anchor bolts on the SAS.**

1. What caused the E2 anchor bolts manufactured in 2008 to fail?

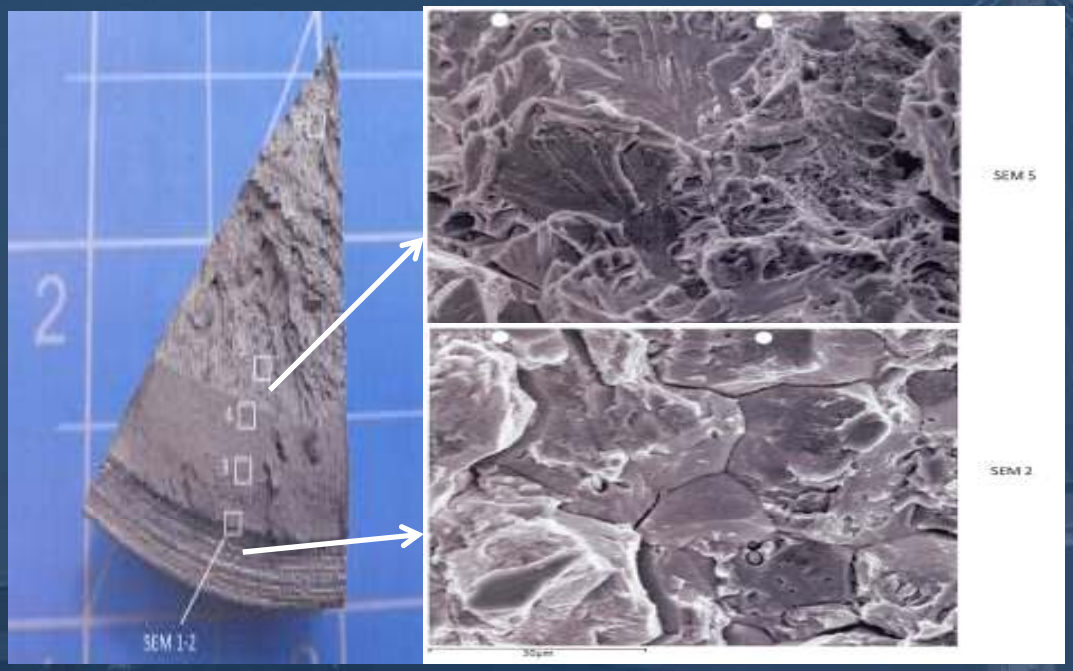


- **Bearings and shear keys are secured to E2 by 3 inch diameter bolts, ranging from 9 feet to 24 feet in length and to the OBG by 2 to 3 inch diameter bolts ranging 2 to 5 feet in length.**
- **96 bolts manufactured in 2008 shown in red are embedded in the pier..**

Failure of 2008 Bolts Due to Hydrogen Embrittlement

- Under detailed investigation by Caltrans and the Contractor, 2008 bolt failures are due to hydrogen embrittlement.
- Excess hydrogen in the 2008 bolts caused the threaded areas of bolts to become brittle and fracture under high tension.

Hydrogen Embrittlement



1000X Magnification

- Metallurgical analysis indicates 2008 bolts were susceptible to hydrogen embrittlement due to "a lack of uniformity in the microstructure of the steel."

Recommendation

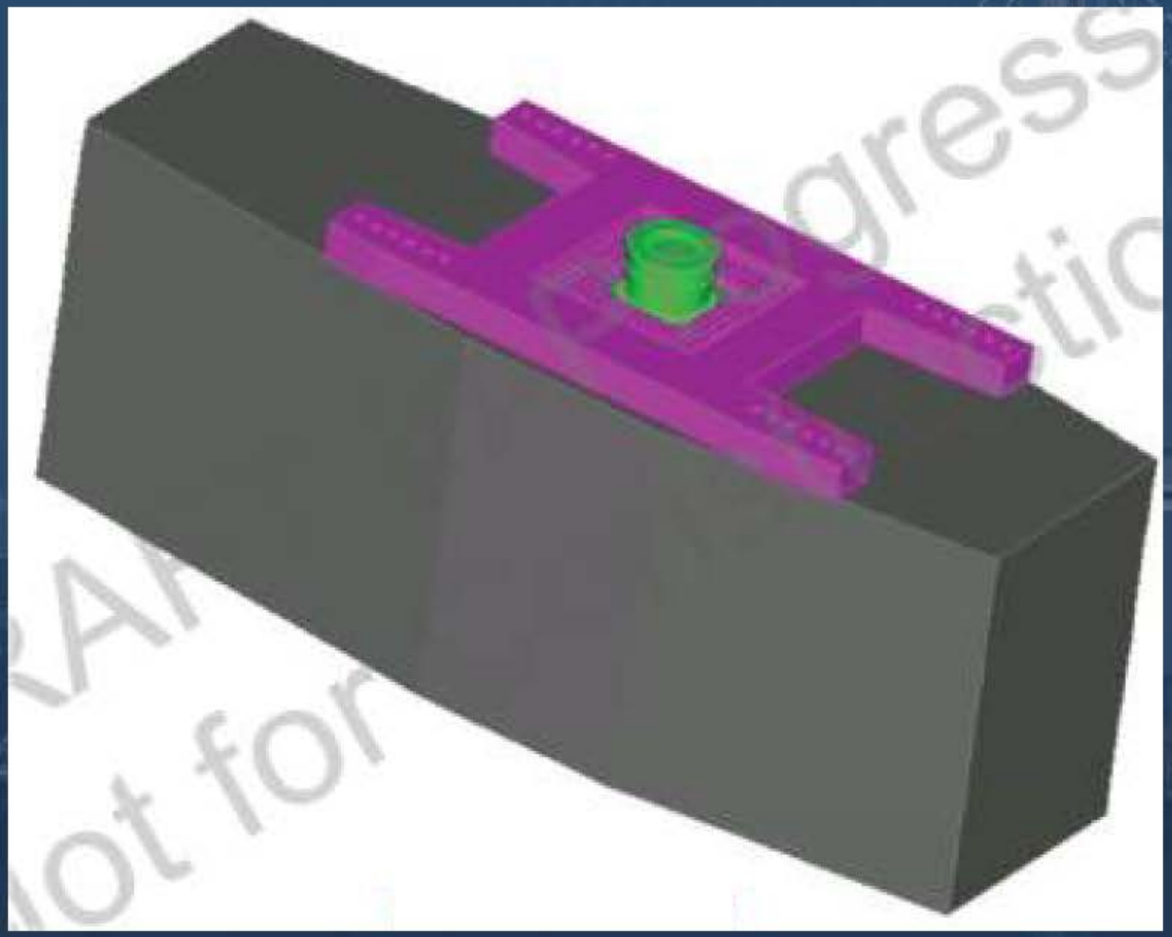
- **Additional supplementary requirements designed to ensure selection of high quality, high hardenability steel that can be heat treated and galvanized to provide bolts with an optimal combination of strength, toughness and uniform microstructure through the entire cross section.**

Specifications for Galvanized A354 BD Bolts

- The east span project is tied to Caltrans 1995 Bridge Design Specifications as well as other design standards and specifications.
- In early 2000's, a technical design specification team evaluated the bridge design and selected a galvanized A354 BD bolt for this application.
- The design specification team added a supplemental requirement – blasting instead of pickling – to address the potential for hydrogen embrittlement.
- Early 2000 Caltrans Bridge Design Specifications were issued that eliminated galvanization of A354 BD fasteners for standard uses

2. What retrofit strategy should be used to replace the 2008 anchor bolts?

Option 1 – Steel Collar



Option 2 – Steel Saddle

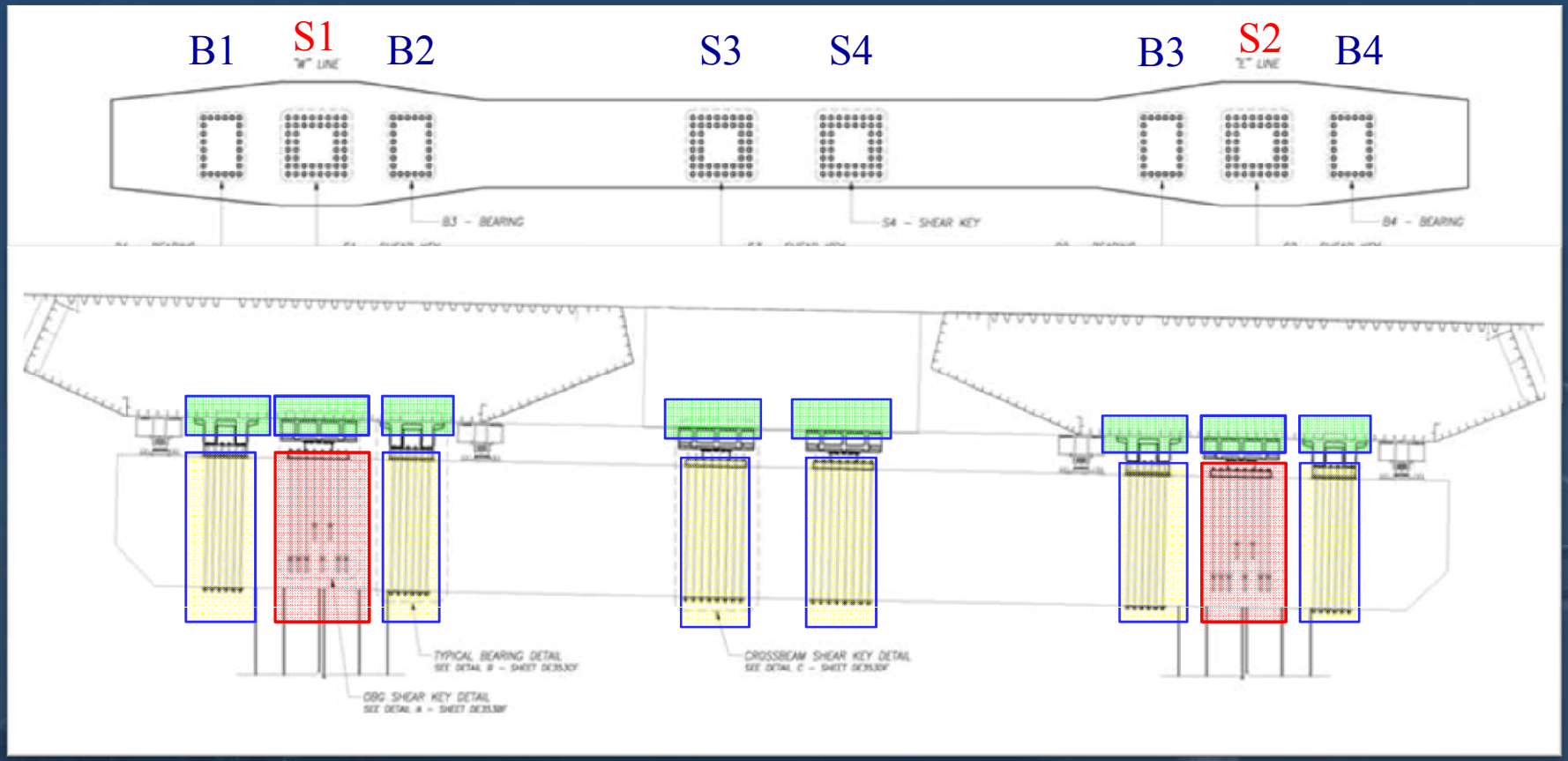
General Comparison of Options

Option 1 – Steel Collar	Option 2 – Steel Saddle
Pros • No need to remove S1 and S2 shear keys • Potentially simpler to fabricate	Pros • No need to remove S1 and S2 shear keys • Less coring of E2 required • Potentially less difficult to install. • Less costly: $5 m
Cons • Need to find sufficient materials and resources • More coring of E2 required • More costly: $16 m	Cons • Requires unique saddle system.

Selection of Option 2 - Saddle

- Both options would provide equivalent clamping force as the original bolt design to hold down the shear keys. The 2008 bolts will be completely abandoned in both options.
- Option 2 has been selected as the retrofit strategy for the 2008 bolts because while requiring more detailed fabrication, installation will be less difficult and require less coring of concrete on Pier E2.
- Estimated cost to construct Option 2 is $5 m.
- Estimated time to construct Option 2 is ___ months.

3. Should the remaining bolts on the E2 pier manufactured in 2010 be replaced?



- 96 bolts manufactured in 2008 shown in red are embedded in the pier.
- 192 bolts manufactured in 2010 shown in blue are not embedded in pier.
- 544 bolts manufactured in 2010 shown in green are connected to the OBG.
- There are an additional 432 bolts of 1 inch diameter, varying from 2 inches to 2 feet in length, that are internal to the E2 bearing assembly.

Preliminary 2010 Bolt Results

- No bolts have broken after more than a month of tensioning.
- Preliminary test results for 2010 bolts show more ductile material properties and no hydrogen embrittlement.
- Additional testing results are anticipated, including surface hardness, microscopic examination, and corrosion testing.

Post Heat Treatment QC/QA Mechanical Tests of E2 Bolts

	Tensile (KSI)	Yield (KSI)	Elongation (%)	Reduction of Area (ROA)	Hardness (Rockwell C)
2008 E2 Bottom Average	164	142	14	48	37
2010 E2 Bottom Average	159	139	16	51	34
E2 Shear Key Top Average	159	141	16	46	35
E2 Bearing Top Average	161	135	16	54	35
E2 Bearing Assembly Average	166	154	18	56	36
E2 Retaining Ring Average	166	148	16	50	35

Stress Corrosion

- **Long term stress corrosion susceptibility is a function of the size and harness of material, and level of tensioning.**

- **Staff will be evaluating the high-strength bolts used on the project to determine if additional remedial action is needed.**

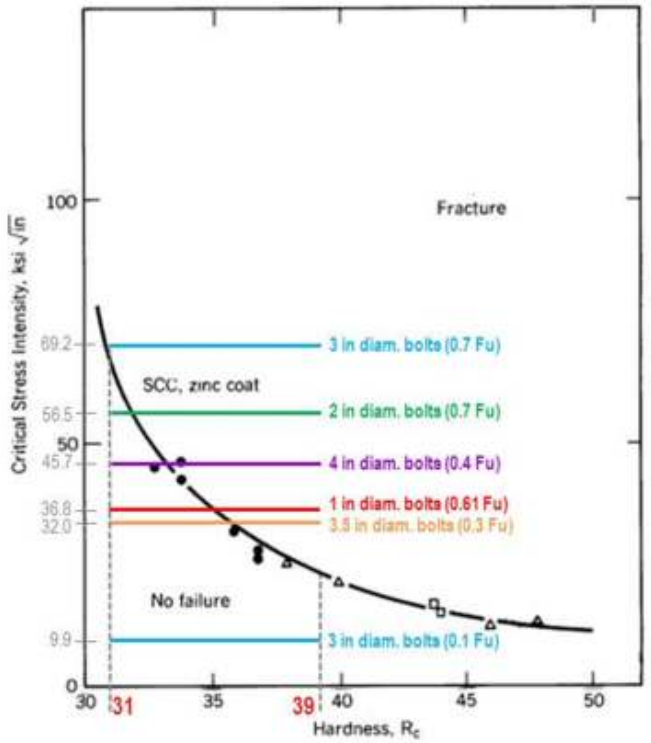
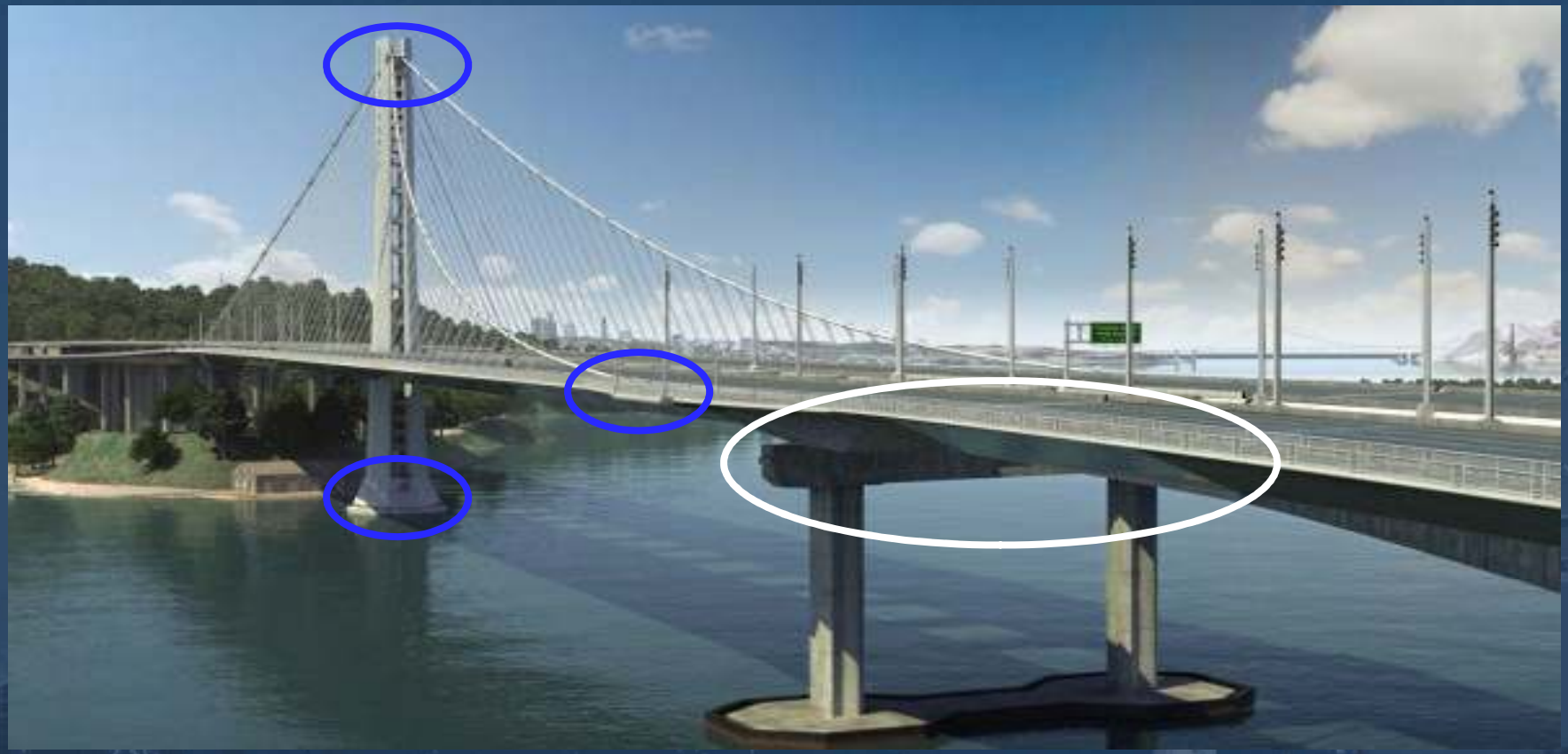


Fig 4.28. Critical Stress intensities in presence of corrosive environment; • K_{ic}, hot-dip Al-Zn; ▲ K_{ic}, electroplated zinc; ■ K_{ic}, hot-dip zinc.

Wet Testing of 2010 Bolt Results

- A "wet" test is an accelerated test being prepared to determine the longer term susceptibility of the material to stress corrosion.
- Full sized bolts will be soaked in a controlled concentrated salt solution while tensioned progressively over a number of days until failure.
- Data from this test will be used to determine the susceptibility of the material to stress over time and under various loads.

4. What should be done about the other A354 bolts on the SAS?



- **Visual inspections of similar anchor bolts revealed they are performing as required.**
- **Some E2 Bearing assembly bolts are not accessible to inspection.**
- **Most anchor bolts at other locations are under lower tension levels.**

Other Anchor Bolts

Location	Item No.	Description	Diameter (in)	Length (ft)	Quantity Installed	Tension (fraction of Fu)
E2	1	2008 Shear Keys Bolts	3	10 – 17	96	0.7
	2	2010 Shear Keys and Bearing Bolts	3	22 - 23	192	0.7
	3	Upper Shear Key OBG Connections	3	2 - 4.5	320	0.7
	4	Upper Bearing OBG Connections	2	4	224	0.7
	5	Bearing Assembly Bolts for Bushings	1	2.5	96	0.6
	6	Bearing Assembly Bolts for Retaining Rings	1	0.2	336	0.4
Anchorage	7	PWS Anchor Rods	3.5	28 – 32	274	0.4
Top of Tower	8	Saddle Tie Rods	4	6.0 – 18	25	0.4
	9	Saddle Segment Splices	3	1.5 – 2	108	0.1 - 0.5
	10	Saddle to Grillage Anchor Bolts	3	1	90	0.1
	11	Outrigger Boom	3	2	4	0.1
Bottom of Tower	12	Anchor Rods 3"	3	26	388	0.5
	13	Anchor Rods 4"	4	26	36	0.4
East Saddles	14	East Saddle Anchor Rods	2	3	21	0.1
	15	East Saddle Tie Rods	3	5	18	0.1
East Cable	16	Cable Bands	3	10 - 11	24	0.2
W2	17	Bikepath Anchor Rods	1 3/16	1.5	43	tbd
				TOTAL	2306	

Other Bridges

- As part of this investigation, the TBPOC has learned that retrofit work on other toll bridges used similar bolts, including on the Richmond-San Rafael Bridge.

- Inspections of these bolts are underway; thus far no abnormalities have been revealed.

Items Expected at May 29th Briefing

- Pending results from testing of 2010 bolts, decision on whether to replace Pier E2 bolts and, if so, when.
- Completion of desk review of additional QA/QC results for other high tension anchor bolt locations.